

## WHAT IS CLAIMED IS:

1. An intake air amount control apparatus for an internal combustion engine comprising:

5 an opening control mechanism for controlling an opening of a throttle valve disposed on an intake path of the internal combustion engine;

a variable valve mechanism for varying opening/closing characteristics of at least one of an intake valve and an exhaust  
10 valve of the internal combustion engine;

an intake characteristics change mechanism for changing intake characteristics of the internal combustion engine by controlling a parameter or parameters different from (i) the opening of the throttle valve and (ii) the opening/closing characteristics of  
15 said at least one of the intake valve and the exhaust valve;

an intake amount control device for controlling an intake air amount supplied into a combustion chamber of the internal combustion engine by performing a cooperative control of said opening control mechanism, said variable valve mechanism and said  
20 intake characteristics change mechanism;

an abnormality detection device for detecting an abnormal condition in said opening control mechanism and said variable valve mechanism; and

a fail-safe device for controlling said opening control  
25 mechanism, said variable valve mechanism and said intake characteristics change mechanism, in case that the abnormal

condition is detected by said abnormality detection device in one of  
said opening control mechanism and said variable valve mechanism,  
so as to control the intake air amount by the other of said opening  
control mechanism and said variable valve mechanism, in place of  
5 the cooperative control by said intake amount control device.

2. The intake air amount control apparatus according to claim 1,  
wherein said fail-safe device fixes (i) a control amount by the one of  
said opening control mechanism and said variable valve mechanism  
10 and (ii) a control amount by said intake characteristics change  
mechanism, to constant values in spite of an operation condition of  
the internal combustion engine, in case that the abnormal condition  
is detected in the one of said opening control mechanism and said  
variable valve mechanism.

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3. An intake air amount control apparatus for an internal  
combustion engine comprising:

an opening control mechanism for controlling an opening of a  
throttle valve disposed on an intake path of the internal combustion  
20 engine;

a variable valve mechanism for varying opening/closing  
characteristics of at least one of an intake valve and an exhaust  
valve of the internal combustion engine;

an intake characteristics change mechanism for changing  
25 intake characteristics of the internal combustion engine by  
controlling a parameter or parameters different from (i) the opening

of the throttle valve and (ii) the opening/closing characteristics of said at least one of the intake valve and the exhaust valve;

an intake amount control device for controlling an intake air amount supplied into a combustion chamber of the internal combustion engine by performing a cooperative control of said  
5 opening control mechanism, said variable valve mechanism and said intake characteristics change mechanism;

an abnormality detection device for detecting an abnormal condition in said intake characteristics change mechanism; and

10 a fail-safe device for controlling said opening control mechanism, said variable valve mechanism and said intake characteristics change mechanism, in case that the abnormal condition is detected by said abnormality detection device in said intake characteristics change mechanism, so as to control the intake  
15 air amount by one of said opening control mechanism and said variable valve mechanism, in place of the cooperative control by said intake amount control device.

4. The intake air amount control apparatus according to claim 3,  
20 wherein said fail-safe device fixes (i) a control amount by said intake characteristics change mechanism and (ii) a control amount by the other of said opening control mechanism and said variable valve mechanism, to constant values in spite of an operation condition of the internal combustion engine, in case that the  
25 abnormal condition is detected in said intake characteristics change mechanism.

5. An intake air amount control apparatus for an internal combustion engine comprising:

an opening control mechanism for controlling an opening of a throttle valve disposed on an intake path of the internal combustion engine;

a variable valve mechanism for varying opening/closing characteristics of at least one of an intake valve and an exhaust valve of the internal combustion engine;

an intake characteristics change mechanism for changing intake characteristics of the internal combustion engine by controlling a parameter or parameters different from (i) the opening of the throttle valve and (ii) the opening/closing characteristics of said at least one of the intake valve and the exhaust valve;

an intake amount control device for controlling an intake air amount supplied into a combustion chamber of the internal combustion engine by performing a cooperative control of said opening control mechanism, said variable valve mechanism and said intake characteristics change mechanism;

an abnormality detection device for detecting an abnormal condition in said opening control mechanism, said variable valve mechanism and said intake characteristics change mechanism; and

a fail-safe device for controlling said opening control mechanism, said variable valve mechanism and said intake characteristics change mechanism, in case that the abnormal condition is detected by said abnormality detection device in one of

said opening control mechanism, said variable valve mechanism and  
said intake characteristics change mechanism, so as to control the  
intake air amount by another of said opening control mechanism,  
said variable valve mechanism and said intake characteristics  
5 change mechanism, in place of the cooperative control by said intake  
amount control device.

6. The intake air amount control apparatus according to claim 5,  
wherein said fail-safe device fixes (i) a control amount by the one of  
10 said opening control mechanism, said variable valve mechanism and  
said intake characteristics change mechanism and (ii) a control  
amount by another of said opening control mechanism, said variable  
valve mechanism and said intake characteristics change mechanism,  
to constant values in spite of an operation condition of the internal  
15 combustion engine, in case that the abnormal condition is detected  
in the one of said opening control mechanism, said variable valve  
mechanism and said intake characteristics change mechanism.

7. The intake air amount control apparatus according to claim 3,  
20 wherein said fail-safe device controls said opening control  
mechanism, said variable valve mechanism and said intake  
characteristics change mechanism, in case that the abnormal  
condition is detected in said intake characteristics change  
mechanism, so as to control the intake air amount by said opening  
25 control mechanism.

8. The intake air amount control apparatus according to claim 5,  
wherein said fail-safe device controls said opening control  
mechanism, said variable valve mechanism and said intake  
characteristics change mechanism in case that the abnormal  
5 condition is detected in said variable valve mechanism or said  
intake characteristics change mechanism as the one of said opening  
control mechanism, said variable valve mechanism and said intake  
characteristics change mechanism, so as to control the intake air  
amount by said opening control mechanism as the another of said  
10 opening control mechanism, said variable valve mechanism and said  
intake characteristics change mechanism.

9. The intake air amount control apparatus according to claim 2,  
wherein the constant values are values which relatively reduce  
15 concentration of predetermined impurity or impurities in an  
exhaust gas generated by the internal combustion engine.

10. The intake air amount control apparatus according to claim 4,  
wherein the constant values are values which relatively reduce  
20 concentration of predetermined impurity or impurities in an  
exhaust gas generated by the internal combustion engine.

11. The intake air amount control apparatus according to claim 6,  
wherein the constant values are values which relatively reduce  
25 concentration of predetermined impurity or impurities in an  
exhaust gas generated by the internal combustion engine.

12. The intake air amount control apparatus according to claim 2,  
wherein the constant values are values corresponding to the  
operating condition in a partial load area of the internal combustion  
5 engine.

13. The intake air amount control apparatus according to claim 4,  
wherein the constant values are values corresponding to the  
operating condition in a partial load area of the internal combustion  
10 engine.

14. The intake air amount control apparatus according to claim 6,  
wherein the constant values are values corresponding to the  
operating condition in a partial load area of the internal combustion  
15 engine.

15. The intake air amount control apparatus according to claim 1,  
wherein said intake characteristics change mechanism includes at  
least one of (i) a swirl control valve for controlling the intake air  
20 amount by adjusting swirl in the combustion chamber, (ii) a variable  
intake system control valve for controlling the intake air amount by  
adjusting an intake path leading to the combustion chamber and  
(iii) a timing change mechanism for controlling the intake air  
amount by adjusting opening/closing timing of at least one of the  
25 intake valve and the exhaust valve.

16. The intake air amount control apparatus according to claim 3, wherein said intake characteristics change mechanism includes at least one of (i) a swirl control valve for controlling the intake air amount by adjusting swirl in the combustion chamber, (ii) a variable  
5 intake system control valve for controlling the intake air amount by adjusting an intake path leading to the combustion chamber and (iii) a timing change mechanism for controlling the intake air amount by adjusting opening/closing timing of at least one of the intake valve and the exhaust valve.

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17. The intake air amount control apparatus according to claim 5, wherein said intake characteristics change mechanism includes at least one of (i) a swirl control valve for controlling the intake air amount by adjusting swirl in the combustion chamber, (ii) a variable  
15 intake system control valve for controlling the intake air amount by adjusting an intake path leading to the combustion chamber and (iii) a timing change mechanism for controlling the intake air amount by adjusting opening/closing timing of at least one of the intake valve and the exhaust valve.

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18. An intake air amount control method for an internal combustion engine of controlling an intake air amount of the internal combustion engine by performing a cooperative control of (I) an opening control mechanism for controlling an opening of a  
25 throttle valve disposed on an intake path of the internal combustion engine, (II) a variable valve mechanism for varying opening/closing



characteristics of at least one of an intake valve and an exhaust valve of the internal combustion engine and (III) an intake characteristics change mechanism for changing intake characteristics of the internal combustion engine by controlling a  
5 parameter or parameters different from (i) the opening of the throttle valve and (ii) the opening/closing characteristics of at least one of the intake valve and the exhaust valve,

wherein said method controls the intake air amount, in case that there is any abnormality in one of said opening control  
10 mechanism, said variable valve mechanism and said intake characteristics change mechanism, only by another of said opening control mechanism, said variable valve mechanism and said intake characteristics change mechanism.